The Pharma Innovation Journal 2018; 7(3): 07-10

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(3): 07-10

www.thepharmajournal.com
Received: 07-01-2018
Accepted: 08-02-2018

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Physico-chemical properties of pseudo-cereals (Amaranth and buckwheat)

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Abstract
Physico-chemical properties of pseudo-cereals (amaranth and buckwheat) were studied. The pseudo-cereals were analyzed for 1000 kernel weight, bulk density, hydration capacity, hydration index, swelling capacity and swelling index. Flour samples from amaranth and buckwheat were analyzed for moisture, crude fat, crude protein, crude fibre, ash, and total carbohydrates. It was revealed that seed size of amaranth was much smaller than buckwheat. Protein and fat content of amaranth was higher than buckwheat whereas, buckwheat was found to be rich in crude fibre content.

Keywords: Physico-chemical, pseudo-cereals, amaranth, buckwheat

Introduction
The pseudo-cereals have attracted much interest in recent years. One of the reasons for this renewed interest is their excellent nutrient profile. In addition to being one of the important energy sources due to their starch content, these pseudo-cereals provide good quality protein and lipids rich in unsaturated fats.
Amaranth, a major pseudo-cereal, is an ancient plant belonging to family amaranthaceae, which is believed to have originated from central and southern America. Owing to their significant starch, protein and lipid content, amaranth seeds can be considered promising raw material for the production of flour, starch and protein. Amaranth contain 62% starch, 17% protein (Silva-Sanchej *et al*., 2008) [36], 9-16% dietary fiber (Pederson, 1987) [27] and good source of vitamin B and minerals (Gamel *et al*., 2006) [15].
Buckwheat (*Fagopyrum esculentum*) commonly known as "kuttu" is a non-glutinous pseudo-cereal belonging to the family polygonaceae. The triangular shaped seeds make it similar to a beech nut therefore, the name is may be modification of "beech wheat" (Singh and Atal, 1982) [34]. It contains 67-75% starch, 7-21% protein, 1.2-4.3% lipids, and appreciable amount of dietary fiber and minerals (Przybylski and Gruczynska, 2009) [28]. The present study was carried out to examine the physical properties and chemical composition of amaranth and buckwheat in order to identify their potential application as food ingredients.

Material and methods
The experiment was conducted at Choudhary Charan Singh Haryana Agricultural University, Hisar during 2015-2016**.** Amaranth seeds were procured from the Department of Plant Breeding, CCSHAU, Hisar. Buckwheat seeds were procured from Regional Research Centre, Sangla, Himachal Pradesh Krishi Visavavidyalaya, Palampur, Himachal Pradesh. Pseudo-cereals were cleaned for extraneous matter and flour was prepared by milling in Brabender Quardamat Junior Mill.

Evaluation of grains
Grains of amaranth and buckwheat were assessed for 1000 kernel weight, bulk density, hydration capacity, hydration index, swelling capacity and swelling index.

Thousand Kernel Weight
Thousand grains were counted thrice and weighed. Thousand grain weight expressed as the weight in g per thousand grains.

Bulk Density
Grains were filled in 50 ml measuring cylinder up to 25 ml. The bottom of the cylinder was

tapped gently on a laboratory bench to fill grains properly. Grains were weighed. Bulk density was calculated by dividing weight of sample to volume and expressed as g/ml.

Hydration Capacity and hydration index

Seeds weighing 10 g were counted and transferred to a measuring cylinder. To this 50ml water was added and cylinder was covered with aluminum foil and left overnight at room temperature. The seeds were drained, superfluous water was removed with filter paper and swollen seeds were reweighed. Hydration capacity and hydration index was calculated using the following formula:

$$\text{Hydration capacity (\%)} = \frac{\text{Weight after soaking} - \text{Weight before soaking}}{\text{Weight of seeds}} \times 100$$

$$\text{Hydration capacity (per seed)} = \frac{\text{Weight after soaking} - \text{Weight before soaking}}{\text{Number of seeds}}$$

$$\text{Hydration index} = \frac{\text{Hydration capacity per seed}}{\text{Weight of one seed}}$$

Swelling capacity and swelling index

Seeds weighing 10 gm were counted, transferred to a measuring cylinder and their volume was recorded. To this 50 ml water was added and cylinder was covered with aluminum foil and left overnight at room temperature. The water was drained and volume of soaked seeds was noted in graduated cylinder. Swelling capacity and swelling index was calculated using the following formula:

$$\text{Swelling capacity (\%)} = \frac{\text{Volume after soaking} - \text{Volume before soaking}}{\text{Weight of seeds}} \times 100$$

$$\text{Swelling capacity (per seed)} = \frac{\text{Volume after soaking-Volume before soaking}}{\text{Number of seeds}}$$

$$\text{Swelling index} = \frac{\text{Swelling capacity per seed}}{\text{Seed volume (ml)}}$$

Chemical evaluation

Flour samples from HQPM varieties were analyzed for moisture, crude fat, crude protein, crude fibre, ash, and total carbohydrates using standard methods of AOAC (1995) [3].

Results and Discussion

Table 1: Physical properties of pseudo-cereals

Sample	1000 kernel weight (g)	Bulk density (g/ml)	Hydration index	Swelling index
Pseudo-cereals				
Amaranth	0.51±0.003	0.66±0.00	0.80±0.003	0.63±0.003
Buckwheat	23.73±0.11	0.69±0.00	0.57±0.003	0.96±0.003

Thousand kernel weight of amaranth (0.51 g) recorded in the present study was within the range of weight (0.46 – 0.70 g/1000grains) observed for 11 lines of *amaranthuscaudatus* by Kaur *et al.,* (2010) [19] and lower than the value (0.55 – 1.04 g) reported by Gimplinger *et al.,* (2007) [14]. Thousand kernel weight of buckwheat grains was 23.73 g (Table 1) was comparable with the weight/1000grains (23.92 g) observed by Pandey *et al.,* (2015) [26] and higher than the range (1.60-2.19 g/100 seeds) reported by Kumari and Raghuvanshi (2015) [23]. Variation in 1000 kernel weight of different grains of pseudo-cereals may be attributed to varietal characteristic which is influenced by the size of the grains (Cheik *et al*., 2006) [11] and moisture content of grains (Balasubramanian *et al*., 2010) [5]. Bulk density of amaranth seeds (0.66 g/ml) observed in present study was lower than the values (720–840 kg/m$^{3)}$ reported by Abalone *et al.*, (2004) [1]. Bulk density of buckwheat was recorded as 0.69 g/ml and was in the range of values (0.48-0.73 g/ml) reported by Kumari and Raghuvanshi (2015) [23] and lower than the value (768 kg/m^3) observed by Pandey *et al.*, (2015) [26]. Variation in bulk density of amaranth and buckwheat may be attributed to the variety, moisture content, seed size and contamination level. Hydration index and swelling index of amaranth (0.80 and 0.63, respectively) and of buckwheat (0.57 and 0.96, respectively) depicted in Table 1 was higher than the value recorded for amaranth (Shyam and Raghuvanshi, 2015) [30] and for buckwheat (Kumari and Raghuvanshi, 2015) [23]. The difference observed for hydration index and swelling index of amaranth and buckwheat may be due to difference in variety, seed size, seed coat permeability, hydrophilic constituent and genetic endowment (Kumar, 2012) [22].

Chemical composition

Table 2: Chemical composition of pseudo-cereals

Sample	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Total carbohydrates
Pseudo-cereals						
Amaranth	9.32±0.05	15.96±0.27	5.75±0.17	3.72±0.03	2.42±0.01	72.14±0.43
Buckwheat	11.31±0.14	10.66±0.00	2.47±0.14	12.86±0.14	1.99±0.007	72.00±0.24

Moisture content of amaranth (9.32%) was comparable with the value (9.75%) reported by Sindhu and Khatkar, (2016) [32] and higher than the value reported by Tanimola *et al.* (2016) [39]. Mendoza and Bressani (1987) [25] reported higher moisture content of amaranth varieties (10.3-10.6%) than the value reported in present study. Moisture content of buckwheat grain was 11.31%. Baljeet *et al.,* (2010)[6] and Demin *et al.,* (2013) [12] also found 11.60 and 10.59% moisture in buckwheat, respectively which was comparable with the value of moisture percent observed in present study. However, Pandey *et al.,* (2015) [26] reported lower moisture content of buckwheat.

Amaranth and buckwheat contained 15.96 and 10.66% protein, respectively. Protein content observed in present study was in the range of the values (15.33-18.19%, 6.6-19.8% and 15.22-18.55%) observed by Becker *et al.*,(1981) [8]; Kaur *et al.,* (2010) [19] and Gimplinger *et al.,* (2007) [14], respectively for different amaranth varieties of amaranth and the values (6.51-11.47%) observed by Ikeda *et al.*, (2004) [16] for buckwheat species. Values for protein content in amaranth

(Babor *et al.*, 1994 and Souci *et al.*, 2000) [4, 35] and buckwheat (Souci *et al.*, 2000) [35] were similar to the values found in the present study. Lower protein content in amaranth (Menegassi *et al.*, 2011; Chauhan and Singh, 2013; Shevkani *et al.*, 2014; Sindhu and Khatkar, 2016 and Tanimola *et al.*, 2016) [24, 10, 29, 32, 39] and in buckwheat (Baljeet*et al.*, 2010 and Batham *et al.*, 2013) [6, 7] have been reported. Alvarez-Jubete *et al.*, (2009) [2] observed higher value of protein in amaranth and Wronkowska and Smietana (2008) [38]; Inglett *et al.*, (2009) [17]; Demin *et al.*, (2013) [12]; Khan *et al.*, (2013) [20]; Vojtiskova *et al.*, (2014) [37]; Pandey *et al.*, (2015) [26]; Deng *et al.*, (2015) [13] and Sindhu and Khatkar (2016) [31] observed higher protein content in buckwheat than the value of protein observed in present study.

Amaranth and buckwheat contained 5.75 and 2.47% fat, respectively (Table 2). Fat content of amaranth was in the range of values reported by Kaur *et al.*, (2010) [19]; Becker *et al.*, (1981) [8] and Gimplinger *et al.*, (2007) [14]. Similar values (5.37-6.0%) of fat were reported by Sindhu and Khatkar, (2016) [32]; Alvarez-Jubete *et al.*, (2010) [2] and Menegassi *et al.*, (2011) [24] for amaranth whereas, Sindhu and Khatkar (2016) [31]; Inglett *et al.*, (2009) [17] and Demin *et al.*, (2013) [12] observed similar values (2.30- 2.83%) for fat content in buckwheat. Higher fat content in amaranth (Mendoza and Bressani, 1987; Babor *et al.*, 1994; Souci *et al.*, 2000; Chauhan and Singh, 2013; Shevkani *et al.*, 2014 and Tanimola *et al.*, 2016) [25, 4, 35, 10, 29, 39] and buckwheat (Pandey *et al.*, 2015 [26]; Deng *et al.*, (2015) [13]; Vojtiskova*et al.*, 2014 [37] and Sindhu and Khatkar, 2016) [33] has been found in comparison to the fat content observed in present study. Khan *et al.*, (2013) [20], Baljeet*et al.*, (2010) [6] and Batham *et al.*, (2013) [7] observed lower value for fat content in buckwheat.

Amaranth and buckwheat contained 3.72 and 12.86% crude fibre, respectively (Table 2). Comparable range of crude fibre (3.23-5.84 and 3.54-4.22%) in amaranth (Becker *et al.*, 1981 and Gimplinger *et al.*, 2007, respectively) [8, 14] and (10.9 and 14.24%) in buckwheat (Inglett *et al.*, 2009 and Pandey *et al.*, 2015, respectively) [17, 26] has been reported. Chauhan and Singh (2013) [10] and Sindhu and Khatkar (2016) [32] observed higher (4.40 and 5.37%, respectively) whereas, Kaur *et al.*, (2010) [19] observed lower (0.30-1.5%) value for crude fibre in *Amaranthus hypochondriacus* lines than the value of crude fibre content observed in present study. Sindhu and Khatkar, (2016) [31, 33]; Demin *et al.*, (2013) [12]; Khan *et al.*, (2013) [20] and Baljeet *et al.*, (2010) [6] also reported lower crude fibre content in buckwheat than found in buckwheat.

Ash content of amaranth and buckwheat was 2.42 and 1.99%, respectively, which was comparable with the values of ash content in amaranth (Kaur *et al.*, 2010) [19] and buckwheat (Alvarej-Jubete *et al.*, 2010 [2]; Inglett *et al.*, 2009 [17] and Sindhu and Khatkar, 2016) [33]. Babor *et al.*,(1994) [4]; Gimplinger *et al.*, (2007) [14]; Alvarez-Jubete *et al.*, (2010) [2]; Shevkani *et al.*, (2014) [29] and Kachiguma *et al.*, (2015) [18] observed higher (2.96, 2.71-3.23, 2.80, 3.0-3.5 and 4.41-8.73%, respectively) ash content in amaranth whereas, Wronkowska and Smietana (2008) [38]; Demin *et al.*, (2013) [12]; Deng *et al.* (2015) [13]; Pandey *et al.*, (2015)[26] and Sindhu and Khatkar (2016) [31] reported higher (2.42, 2.12, 2.33, 2.18 and 2.81%, respectively) ash content in buckwheat than the ash content observed for amaranth and buckwheat in present study. Tanimola *et al.*, (2016) [39] observed lower (1.87%) ash content in amaranth and Souci *et al.* (2000) [35]; Baljeet *et al.* (2010) [6]; Batham *et al.*, (2013) [7] and Khan *et al.*, (2013) [20] observed lower (1.59, 1.42, 1.56 and 1.14-1.62%, respectively) ash content in buckwheat than the value found in the present study.

Amaranth and buckwheat contained 72.14 and 72.00% carbohydrates, respectively (Table 2). 66.71-72.72% carbohydrates has been reported by Gimplinger *et al.*, (2007) [14] for three genotypes of amaranth. Tanimola *et al.*, (2016) [39] also reported similar value for carbohydrates content. Koziol (1992) [21] reported lower (70.3%) whereas, Shevkani *et al.*, (2014) [29] reported higher (73.7-76.4%) value of carbohydrates in amaranth as compared to observed in present study. Baljeet *et al.*, (2010) [6] and Inglett *et al.*, (2009) [17] reported 75.74% and 73.3% carbohydrates, respectively in buckwheat which were higher than the value of carbohydrate content observed in the present study.

Slight variation in the value of carbohydrates, proteins, lipids, fibre and ash in present study may be due to differences in the varieties of grains of pseudo-cereals analyzed and also due to difference in the climatic conditions and cultural practices (Koziol, 1992 and Bressani, 1994) [21, 9].

Conclusion

The present investigation, it was revealed that seed size of amaranth was much smaller than buckwheat. Protein and fat content of amaranth was higher than buckwheat whereas, buckwheat was found to be rich in crude fibre content.

Acknowledgement

The first author is thankful to the Department of Food Science and Technology for their support and courage during research work.

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